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(54)【発明の名称】 超高密度、不揮発性強磁性ランダム・アクセス・メモリ

(57)【要約】
ランダム・アクセス・メモリ要素（100）は、巨大な磁性抵抗を利用する。この要素（100）は、非磁性導電層（108）を挟み込む少なくとも一対の強磁性層（106、110）を有する。その2つの強磁性層の内の少なくとも一つの層には、それ自体の平面の中で配向した磁気モーメントがある。少なくとも対の第1強磁性層の磁気モーメントには、それ自体の平面の中で配向した磁気モーメントがあり、通常、使用中の方向で固定されている。対の第2強磁性層には、第2強磁性層の平面の中に存在する場合もあれば、存在しない場合もある配向の少なくとも2つの望ましい方向を持つ1つの磁気モーメントを有している。メモリ要素のビットは、要素に対して、これらの望ましい配向の一方またはもう一方に第2強磁性層の磁気モーメントを配向する磁界を適用することにより設定することができる。設定値は、第1強磁性層および第2強磁性層の磁気モーメントの相対的な整列状態により決定される。

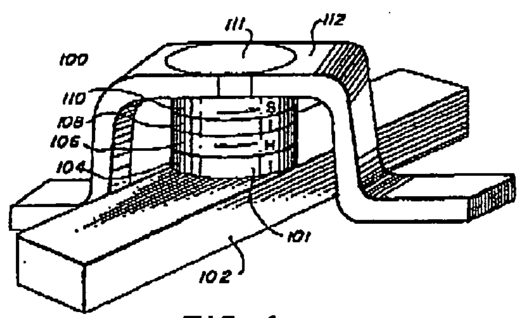

FIG. 4

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CLAIMS

[Claim(s)]
1. It is Non-volatile Ferromagnetism Random-Access-Memory Element, and There are a 1st (a) a Little More Than Magnetic Layer and a 2nd a Little More Than Magnetic Layer. Said at least one 1st a little more than magnetic layer to which either [at least] said 1st a little more than magnetic layer or the 2nd a little more than magnetic layer has the magnetic moment in the same flat surface, and the 2nd a little more than magnetic layer, (b) Said 1st a little more than magnetic layer and the non-magnetic metal layer put between the 2nd a little more than magnetic layers, (c) The 1st edge nonmagnetic conductor layer in the end of said ferromagnetic random-access-memory element, (d) The 2nd edge nonmagnetic conductor layer in the edge of the opposite hand of said non-volatile ferromagnetism random access memory, (e) Are vertical to at least one magnetic moment of said 1st a little more than magnetic layer and the 2nd a little more than magnetic layer. The non-volatile ferromagnetism random-access-memory element possessing said 1st edge conductor layer and the 2nd edge conductor layer which limit the conductive path for passing a current from said 1st magnetic layer to said 2nd magnetic layer through said non-magnetic metal layer.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
Super-high density, non-volatile ferromagnetism random-access-memory detailed description Technical field to which invention belongs When this invention is generally specified further about ferromagnetic memory, it relates to the ferromagnetic memory using huge magnetic resistance and spin polarization.
Prior art The random access memory for computers has been built from the magnetic element over many years. This memory had a dominance point of the non-volatile at the time of losing very high dependability and power, and the life of infinity in use. Since this memory was assembled by handicraft from the three-dimension ferrite element, it was replaced by the plane array of a semi-conductor element at last. The plane array of a semi-conductor is farther [than the costs which manufacture the magnetic ferrite memory element by the Prior art] cheap, and can be manufactured with lithography.
Furthermore, these semi-conductor arrays are compact and more nearly high-speed than the ferrite magnetism memory element by the Prior art. Since the semi-conductor element of magnitude with the future now very small dominance point of semiconductor memory that small-scale-ization progresses increasingly is not electrically strong, it is facing a crisis with concern called loss of dependability.
The non-volatile magnetism memory element read by measuring resistance is proved by Honeywell, Inc. (Honeywell Corporation) in the past. These systems operate based on the classic anisotropy magnetism resistance phenomenon which produces a difference to resistance as a result, when orientation of the magnetization is vertically carried out to a current to parallel. In order to have enabled the fabrication of the memory array which is compatible with the existing CMOS computer electronics from research of the past by the others, it came out enough by 2% of change of resistance, and a certain thing was understood. It is difficult to reduce these elements to a regrettable thing from current 1-micrometer size.
Technical problem which invention tends to solve Therefore, this invention sets it as the 1st object to create cheap non-volatile random access ferromagnetism memory.
The 2nd object of this invention is creating non-volatile ferromagnetism random access memory more nearly high-speed than semi-conductor random access memory available now.
The 3rd object of this invention is creating non-volatile random access ferromagnetism memory [KOMPATATO / altitude].
The above object and object added are attained by the non-volatile random-access-memory element using huge magnetic resistance (GMR), i.e., the spin bulb effectiveness. This memory element has sandwich structure which has spacing vacated by one layer to which two or more layers to which one of them changes from a ferromagnetic with that magnetic moment by which orientation is carried out in the flat surface of a layer at least change from non-magnetic metal. Vertically, the magnetic moment to which a conductor lead part changes from at least one ferromagnetic layer to which orientation of the magnetic moment is carried out in the flat surface of a ferromagnetic layer is provided with a current so that two or more ferromagnetic layers may be passed. Between one and the conductor lead parts of a ferromagnetic layer, and one and the conductor lead part of a ferromagnetic layer may be contacted physically, and one antiferromagnetism layer may exist. This antiferromagnetism layer fixes the direction and magnitude of the magnetic moment of a ferromagnetic layer which it contacts.

If an electrical potential difference is applied ranging over the ferromagnetic layer whose number is two, resistance will change according to whether for the magnetic moment of these layers to have received mutually and to have aligned in the same direction.
The magnetic moment of these two ferromagnetic layers has not aligned in the same direction, i.e., in antiparallelism (anti-alignment), the resistance between two layers increases, or it has not stood in a line tidily. The direction where the magnetic moment of these two ferromagnetic layers is originally the same (parallel)
When it is alike or moves from the orientation of reverse parallel more to still more nearly parallel orientation, the resistance between two layers falls. Although the value of "0" or "1" can be specified as a still more nearly parallel condition, the value of "1" or "0" can be specified more as the condition of reverse parallel, respectively. Therefore, the alignment condition of each memory element of having followed this invention expresses 1 bit of information.
A bit is the object which generates sufficient field to align the magnetic moment of the ferromagnetic layer which is not being fixed in one direction along with one of the easy directions of orientation, and can be changed in the memory element according to this invention by applying a current high enough to a conductor lead part. Needless to say, the direction of the orientation which an orientation current likes is determined by the polarity of the orientation current. Once a bit is set up, it can apply a lower current through a suitable conductor lead part, and can read it by judging whether resistance exceeds resistance of criteria resistance, or it is less.
Easy explanation of a drawing If the accompanying drawing showing the structure or the element with the same similar figure in the example shown below and various drawings is referred to, he will be able to understand this invention still more nearly thoroughly.
Drawing 1 is a non-volatile random-access-memory element according to the example of this invention.
Drawing 2 is the top view of the array of non-volatile random access memory according to this invention.
Drawing 3 shows selectively the condition that the magnetic moment of two ferromagnetic layers in the non-volatile random access memory according to drawing 1 is not tidily located in a line.
Drawing 4 is the 2nd example of the non-volatile random-access-memory element according to the example of this invention. This example uses the hard ferromagnetism layer and elasticity ferromagnetism layer which were piled up by turns.
Drawing 5 a and drawing 5 b are the schematic diagrams of the 2 "in quiescent state" ** configuration of the non-volatile random-access-memory element according to this invention using the hard ferromagnetism layer piled up by turns and an elasticity ferromagnetism layer.
Drawing 6 is the top view of the array of non-volatile random access memory according to this invention, and illustrates the means for accessing the memory element in an array and magnetic-pole-izing.
Drawing 7 is the top view of the 5-bit WORD tree possessing the random-access-memory element according to this invention.
Drawing 8 shows the 1st step of the instantiation-process for manufacturing the array of the random-access-memory element which suited this invention the bottom.
Drawing 9 shows the 2nd step of the instantiation-process for manufacturing the array of a random-access-memory element according to this invention.
Drawing 10 shows the 3rd step of the instantiation-process for manufacturing the array of a random-access-memory element according to this invention.
Drawing 11 shows the 4th step of the instantiation-process for manufacturing the array of a random-access-memory element according to this invention.
Drawing 12 shows the 5th step of the instantiation-process for manufacturing the array of a random-access-memory element according to this invention.
Drawing 13 shows the 6th step of the instantiation-process for manufacturing the array of a random-access-memory element according to this invention.
Drawing 14 a and drawing 14 b show the plane non-volatile random-access-memory element according

to this invention in two different configurations "in a quiescent state."
Drawing 15 shows the array of a plane non-volatile random-access-memory element according to drawing 14.
Drawing 16 a and 16b, 16c, and 16d are a series of drawings illustrating the non-volatile random access memory according to a fabrication and this invention.
Drawing 17 is the top view of another example of the non-volatile ferromagnetism memory element according to this invention.
Drawing 18 is the top view of example of the non-volatile ferromagnetism memory element according to this invention another again.
Example The carrier in a device can identify according to the "rise" or a "down" condition only as an electron and an electron hole. The light by which polarization was carried out can create, control and measure the electron flow by which spin polarization was carried out by passing a cross polarization child by passing between the magnetic films which can rotate the relative magnetic moment the same with it being easily controllable. Generally spin polarization specifies itself as special resistance within the magnetic circuit element called magnetic resistance. Modern expression of this magnetic resistance should not be confused with an old opinion with a carrier common to the semi-conductor and metal in which polarization is only carried out by the Lorentz force (VxB) classic when a field exists. This modern effectiveness is purely quantum-mechanical, and when two ferromagnetic metals are divided with nonmagnetic lead wire, it generates. When a carrier flows on another side from one magnetic metal with bias voltage through the intervening lead wire, a carrier's spin polarization plays a dominant role. Since the carrier who leaves the 1st ferromagnetism metal is emitted from the band condition by which polarization was carried out highly, he polarizes highly. The resistance for which the intersection used as a close wax depends on the 2nd a little more than magnetic layer to the spin polarization of a condition strongly is available by those conditions. When the strong magnetic moment of two magnetic metals has aligned, spin description of a condition is the same by two bodies, and a carrier passes through between them freely. When the two moments are anti-alignment, an opposite label (that is, "a rise" by the 1st a little more than magnetic layer is "a down" by the 2nd a little more than magnetic layer) is attached to a condition, and since the condition that they enter decreases further, a carrier understands what still higher resistance will be experienced for. This phenomenon is called the spin bulb effectiveness to current and a general target. Only by measuring resistance between two magnetic layers, it can judge whether they are whether the magnetic moment is parallel or reverse parallel.
This invention uses this spin bulb effectiveness as a foundation of a memory element. two conditions of parallel and reverse parallel with the memory element of this invention -- two bits "0"
"1" is expressed. If the value "1" will be specified as an antiparallelism condition if the value "0" is specified as a parallel condition, the value "1" is specified as a parallel condition and the value "0" will be specified as an antiparallelism condition, it cannot be overemphasized that the value of "0" or "1" can be specified as each condition at arbitration. The condition of a memory element can be easily asked by measuring resistance.
In the research in early stages of reasonable on the spin bulb effectiveness, the migration within a flat surface was measured, and it was dependent on the quantum distributed between magnetic layers as the electron spread to the magnetic layer at parallel. This un-optimal orientation produced change of resistance called **R/R=0.45 within the sandwiches multilayered at the room temperature. The newest research and this invention spread a current at right angles to a layer (that is, vertical migration by which spin polarization was carried out), make effectiveness the maximum, and produce lifting of **R/R of a figure single [a maximum of]. This maximization is produced as a result of eliminating or reducing the shunt effectiveness of the non-magnetic layer in parallel migration. In contrast with the vertical migration system of this invention, in a parallel migration system, since much non-spin distributions EVENS can be generated according to such shunt effectiveness, the magnetic resistance effectiveness fades.
In order to acquire the effective magnetic resistance effectiveness by the spin polarization system, the carrier with whom polarization was carried out needs to move a memory element by time amount

shorter than the relaxation time. The device in which a polarization finishing carrier's (for example, granularity of a spin orbital distribution; magnetic domain wall; interface by the defect or the impurity; uneven magnetization; and change of the crystal structure) spin is reversed is complicated, and the interaction of these devices is not understood thoroughly. Now in spite of it, producing the great portion of **R/R effectiveness from the spin distribution on an interface instead of bulk distribution inside a ferromagnetic layer has clarified. Therefore, it is necessary to make as thin as possible the ferromagnetic layer and the other layer of what kind of memory element created according to this invention. Only the thickness of some mere atomic layers in a ferromagnetic is needed for producing the spin polarization needed actually. Furthermore, both a magnetic layer and a non-magnetic layer must be small as much as possible, and this suggests the high purity substance in structure without a defect. How the structure where this defect does not exist is important is the fully adjusted crystal structure (Fe/Cr and Cu/Co). It is supported by the result which shows bringing about the large spin polarization effectiveness rather than a system like ** and Co/Ag which is not adjusted brings.

Since it is the geometry of the two dimensional array which takes a magnetic memory element and them in, it is having two different desirable approaches especially described by application of this invention. Although both these approaches are dependent on the spin bulb effectiveness, the 1st approach uses sandwich structure similar to the quantum dot of semiconductor technology, and the 2nd approach uses the plane sequence of a magnetic metal stripe. An activity of the focused ion beam grinding in the spot forms the latter structure most easily to being most easily manufactured, if the former structure uses high resolution lithography.

In one approach, a magnetic memory element possesses at least two or more layers accumulated vertically. One simple example of this structure accumulated vertically is shown in drawing 1 , and it can be used for explaining some of fundamental concepts of this invention. The memory element 10 in drawing 1 possesses the pars-basilaris-ossis-occipitalis conductor lead part 12. The top face of the pars-basilaris-ossis-occipitalis conductor lead part 12 supports the underside of the layer 11 of non-magnetic metal matter, such as Cu, and contacts physically. The top face of the nonmagnetic conductor layer 11 supports the layer 14 of an antiferromagnetism (it is (like FeMn)) metal, and contacts physically. He should understand that let the claim following this description and it pass, and the vocabulary the "upper part" and the "lower part" is used as vocabulary on expedient for distinguishing various fields which face mutually. Neither of the "upper parts" or the "lower parts" which are used in the claim following a description and it suggest the orientation about the gravity field of the element of arbitration.

The underside of the layer 16 of ferromagnetic metals, such as Co, is on the top face of the nonmagnetic conductor layer 11, and contacts physically. The ferromagnetic layer 16 is arranged using the known conventional magnetic pole-ized means, consequently the magnetic moment inside the layer comes (that is, it does not jump out of a layer toward the layer which the multistory structure 10 adjoins) to have the direction of the desirable orientation in the flat surface of a layer. The antiferromagnetism layer 14 achieves the function "fixes" the orientation of the magnetic moment in the ferromagnetic layer 16 in this desirable orientation. Originally all change in the orientation of the magnetic moment of the ferromagnetic layer 16 under anticipated use is barred by this immobilization.

The underside of a non-magnetic layer 18 is located on the top face of the ferromagnetic layer 16, it contacts physically, and a role of an intervening non-magnetic layer which is needed for the aforementioned spin bulb effectiveness is played. The top face of a non-magnetic layer 18 supports the ferromagnetic layer 20, and contacts physically. The ferromagnetic layer 20 is arranged using the known and conventional means including magnetic pole-ization, consequently the magnetic moment in the layer comes to have parallel and reverse parallel about the direction of two desirable orientation (that is, it does not jump out of a layer toward the layer which the multistory structure 10 adjoins), for example, the magnetic moment of the ferromagnetic layer 16, in the flat surface of a layer. The base of the up conductor lead part 22 is on the top face of the ferromagnetic layer 20, and contacts physically.

the original orientation of the magnetic moment which the orientation of the magnetic moment in the ferromagnetic layer 20 separates from the desirable orientation temporarily, and the ferromagnetic layers 16 and 20 are alike, respectively, and receives when the current pulse (question pulse) of the die length

of the pars-basilaris-ossis-occipitalis conductor lead part 12 big caudad enough is applied during an activity -- responding -- parallel alignment with the orientation of the magnetic moment of the ferromagnetic layer 16 -- near -- or a variation rate is carried out more distantly.
In order to make reading of the memory element 10 possible, the pars-basilaris-ossis-occipitalis conductor lead part 12 can apply bias electrically about the up conductor lead part 10 in a fixed current circuit (circuit which serves as as [a fixed current] unless it is blocked by the pulse applied externally) (not shown). The monitor of the resistance between the pars-basilaris-ossis-occipitalis conductor lead part 12 and the up conductor lead part 10 is carried out. A small current pulse (question pulse) is applied between this monitor between the pars-basilaris-ossis-occipitalis conductor lead part 12 and the up conductor lead part 10. The magnetic moment of the ferromagnetic layer 20 separates from that orientation that carried out reasonable stability temporarily, and resistance of multistory structure changes with these question pulses. Upheaval of this resistance is detected by the resistance monitor circuit (not shown) which measures the differential value of the dip of resistance in a circuit. It is determined by the electronic circuitry in the electronic circuitry of the device (not shown) using the memory element 10 as which value the value "0" is specified as which condition and the value "0" is specified.
For the object of a working element, the maximum magnetism resistance effectiveness will actually be observed, when the magnetic orientation of the ferromagnetic layers 16 and 18 is parallel (alignment condition) or antiparallelism (anti-alignment condition) either mutually, but in most cases, in order to make fabrication and actuation easy, the direction which makes a sacrifice a certain amount of change of magnetic resistance is a best policy. For example, drawing 3 shows the orientation of the ferromagnetic layer memory elements 50 and 52. The intervening non-magnetic layer 53 is shown by the broken line. As shown by the arrow head of a continuous line, the memory element 50 and the pars-basilaris-ossis-occipitalis ferromagnetism layer 54 of 52 both are fixing the magnetic moment in the same direction. Both the up ferromagnetism layers 56 and 58 of elements 50 and 52 are manufactured so that it may have the two desirable directions of orientation of the magnetic moment. In the example of drawing 3 , these directions of orientation are mutually vertical. The value "0" is specified as arbitration by one side of these desirable directions of orientation shown by the arrow head of the continuous line in a layer 56. In another direction shown by the continuous-line arrow head in a layer 58, the value "1" is specified as arbitration. Since the include angle between the two moments is the same, resistance of such orientation whose number is two is the same. However, when the die length of each pars-basilaris-ossis-occipitalis lead wire (see drawing 1) of each memory elements 50 and 52 is caudad spread by the question current pulse, it generates a field vertical to lead wire, and acts on layers 56 and 58. This field rotates the orientation of layers 56 and 58 towards being shown by the curved dotted-line arrow head. (Although it is also possible to carry out a revolution in the counterclockwise direction by reversing the polarity of the current applied to pars-basilaris-ossis-occipitalis lead wire or the whole up lead wire in order to illustrate, this revolution is shown like right-handed rotation.)
However, the effect to magnetic resistance with the memory elements 50 and 52 of this revolution is opposing. The magnetic moment of a layer 56 is rotated according to the orientation shown by the broken-line arrow head which raises magnetic resistance of the element 50 whole according to an anti-alignment condition since it is near. On the other hand, the magnetic moment of a layer 58 is rotated by revolution of this same right-handed rotation according to the orientation shown by the broken-line arrow head which decreases resistance of the element 50 whole according to an alignment condition since it is near. It is easily measured by passing the reading current which shows clearly whether a bit is "0" and whether these change is "1" through multistory structure.
In order to set up a bit in the memory elements 50 or 52 (that is, it writes in), the simultaneous current pulse which crosses the selected element is transmitted through up current lead wire and lower current lead wire. According to the polarity of a current, the field produced as a result leaves a bit as either "0" or "1." Drawing 2 shows the array 59 of the memory elements 50 and 52 in the desirable array which suppresses a surrounding field from an element to the minimum in order to prevent the crosstalk between adjoining elements. The up conductor lead part 60 and the pars-basilaris-ossis-occipitalis

conductor lead part 62 limit a gridding pattern. The memory elements 50 and 52 are put on the point on which the up conductor lead part 60 crosses the pars-basilaris-ossis-occipitalis conductor lead part 62. The other array within the array 59 of the memory elements 50 and 52 is also possible.
Since it is mainly generated from the spin distribution on an interface, as for the **R/R effectiveness, it is desirable to offer a memory element with multilayer structure and to force die length shorter than spin relaxation Cho into the maximum of an interface. The multilayering memory element which followed this invention for this object possesses the layer accumulated by turns [of the hard magnetic material for which spacing is mutually vacated by the inclusion layer which consists of non-magnetic material, and soft magnetic materials]. In such multilayering structures, although the antiferromagnetism fixed bed may be used, it is not indispensable.
Drawing 4 shows the memory element 100 with two or more interfaces which act on the carrier with whom spin polarization was carried out, and mutual. The structure of the memory element 100 is similar to the structure of the memory element 10 shown in drawing 1 . In order that similar structure may perform a similar function except for the case where it is annotated, in case the suitable matter and a suitable dimension are chosen, intrinsically, the same consideration applies. The memory element 100 possesses the pars-basilaris-ossis-occipitalis conductor lead part 102. The top face of the pars-basilaris-ossis-occipitalis conductor lead part 102 supports the underside of the layer 104 which consists of non-magnetic material, and contacts physically. In existing, the top face of the antiferromagnetism layer 101 of an option is put between the layer 104 of non-magnetic material, and the layer 106 of a hard ferromagnetism metal, and contacts physically. When the antiferromagnetism layer 101 of an option does not exist, the underside of the layer 106 which consists of a hard magnetism ferromagnetism metal like Co is on the top face of a non-magnetic layer 104, and contacts physically. The hard ferromagnetism layer 106 will be arranged using the known conventional means, consequently the magnetic moment in the layer will have the desirable direction of orientation in the flat surface of a layer (that is, it does not jump out of a layer toward the layer which the memory element 10 adjoins).
The underside of a non-magnetic layer 108 is on the top face of the hard ferromagnetism layer 106, it contacts physically, and a role of an intervening non-magnetic layer which is needed for the spin bulb effectiveness is played. The top face of a non-magnetic layer 106 supports the elasticity ferromagnetism layer 110, and contacts physically. The ferromagnetic layer 110 is arranged using the known conventional means, consequently the magnetic moment in the layer comes to have the direction of two desirable orientation. These directions exist in the flat surface of a layer (that is, these directions do not jump out of a layer toward the layer which the memory element 100 adjoins). The base of the layer 111 which consists of the conductive non-magnetic material 112 is on the top face of the ferromagnetic layer 110, and contacts physically. moreover, the base 112 of an up conductor lead part -- the top-face top of the ferromagnetic layer 110 -- it is -- physical -- contacting -- a conductor -- the top face of the layer 111 which consists of non-magnetic material is contacted physically.
The ferromagnetic layer piled up by turns [of two kinds of molds called hard (H mold, layer 106) and elasticity (a smooth S form, layer 110)] is used for the memory element 110. H type layer is high (at

0Öeで、100Öeを上回るのが望ましい）H_H、つまり磁性的

least about 10).に硬質な保持力を有し、S型層は低い（100Öeを下回る）、

It has Hs mold, i.e., holding power [elasticity / in magnetism]. If this array is used, sandwich structure can be easily switched to an anti-alignment condition from an alignment condition only by reversing magnetization of the elasticity ferromagnetism layer 110, with the magnetization direction of the hard ferromagnetism layer 106 fixed.
The array repeated by turns [this] is still more often illustrated with the multilayer multistory structure 200 of drawing 5 a and drawing 5 b. Although the direction of the multistory structure 200 has many layers, in addition to it, it is similar to the multistory structure of the memory element 100 of drawing 4 a configuration and in respect of a function. The pars-basilaris-ossis-occipitalis antiferromagnetism layer

of an option is not illustrated for an up conductor lead part and pars-basilaris-ossis-occipitalis conductor lead part by drawing 5 a and drawing 5 b, either. The ferromagnetic layers 206, 210, 214, and 218 appear by turns between the hard (label "H" is attached) matter, and the elasticity (label "S" is attached) matter. Being put between [of a hard magnetic layer and an elasticity magnetic layer] each pair (204/206;206/208;208/210) is one layer which consists of 212, 214, and 216 of non-magnetic material, respectively.

The memory element 200 has on actuation two configurations "in a quiescent state" which defines "0" bits (drawing 5 a) and "1" bit (drawing 5 b) as arbitration. In the example of drawing 5 a and drawing 8 b, although both these configurations are anti-alignment ("antiferromagnetism") sequences, the phase is reversed. That is, although there is a hard layer to which all have pointed out left-hand side in "0" bits, in "1" bit, all those layers point out right-hand side. In both cases, there is an elasticity layer at a hard layer and an anti-alignment condition. In order to question multistory structure, sufficient pulse and magnetic field H>Hs to reverse the elasticity layer by which orientation is carried out to reverse parallel in the applied pulse and the magnetic field are only applied. the applied pulse -- a hard layer -- reversing -- ** -- it is sufficient magnitude. When the applied fields H are reverse parallel at an elasticity layer, resistance change **R/R continues after this reversal, but as for change, Field H does not happen, in being parallel. The field was pulse-ized and "was read" is offered by the overlay current actuation circuit (**** [it is illustrated and]). Read or OFF

換に必要な100eから1000eの場は、既存の技術によるアン

It is easily obtained by the pulse of a pair peak.

In order "to write in" in a bit, the pulse-ized field increases so that H>HH and a hard layer may be reversed. Generally, since a multilayer system is the minimum energy for it to close magnetic flux of all magnetic layers, it is always reversed in the anti-alignment condition. In order to restore all the elasticity layers even if it does not change a hard layer if, pulse HH>H>Hs of lower level can be offered.

The configuration "under quiescence" of two anti-alignment closeout magnetism circuits illustrated by drawing 5 a and drawing 5 b is very important in order to eliminate a circumference field from an element. However, the momentary alignment which makes the pulse-ized circumference field is between examinations. From the magnitude of this field, the nearest approach of an adjoining element, therefore ultimate recording density are restricted. The reasonable frank engineering solution over this problem is making it not jump out to the element with which the elasticity magnetism "keeper by whom a shunt is done in the upper part of the multistory structure beyond an actuation circuit" is offered in order to collect the line of magnetic flux of a circumference field, and they adjoin. On still more precise level, surrounding stray electromagnetic fields are reducible by reducing the magnetic moment of a layer. Therefore, an elasticity layer and the hard layer itself can be manufactured as a three-tiered structure containing the super-thin layer which consists of the moment conveyance magnetic substance. For example, it was proved by the others that FeMn which is an anti-ferromagnetic body without the network moment can fix one adjoining magnetic layer in magnetism through exchange connection. since all the spin migration effectiveness is originally determined by polarization of an interface -- one or more "hard" layers -- sandwich structure (Co/FeMn/Co) -- or (Fe/FeMn/Fe) -- from -- it is constituted. Polarization of the volume phase by which polarization was carried out to the altitude which consists of Co or Fe will become [being fixed with as in the direction of below the field 2000e, and]. the same -- carrying out -- an elasticity layer -- or (Fe/FeNi/Fe) (Co/FeNi/Co) -- from -- it will be constituted. Although a FeNi (permalloy) layer is easily exchanged very by elasticity, probably it has the small moment and only a few will be useful to the circumference field.

Drawing 6 shows the simple mold matrix 300 which consists of two individual arrays 302 and 304 of the parallel current conveyance bars 306 and 308. As for arrays 302 and 304, it is desirable to carry out orientation to about 90 degrees mutually. The current conveyance bar 306 of an array 302 is on the current conveyance bar 308 of an array 304, and does not touch directly. The current conveyance bars 306 and 308 from arrays 302 and 304 are connected by the accumulated memory element 310 which was put between them at the crossing. The question current over the assignment element of arbitration

appears at the end of one side of these bars 306 or 308, passes an element, escapes from one edge of another contact bars 308 or 306 of each, and comes out. Since another edge of bars 306 and 308 serves as a lead part for measuring fall of potential, it serves as four-point probe measurement of the truth which eliminates the lead partial resistance in a circuit. Only for the object to illustrate, drawing 6 enters through an edge 314, the inside of the multistory structure 310 is flowed, and the question (illustrated by arrow head pointed out in flow direction of line [by which the sign "J" was attached], and current) current 312 ended through the edge 316 of the current conveyance bar 308 of an array 304 is shown. Resistance is measured at the edges 320 and 322 of the assignment current conveyance bar used in this example that counterposes edges 314 and 316, respectively.

A conductive parallel path must be eliminated so that the x-y matrix of drawing 6 can perform true measurement of one element. This target is attained by providing the diode film element 322 at the end of one side of multistory structure which contacts a bar on the current bar with which a current goes into multistory structure, or in either the bottom. In order that all currents may pass an element by one-way traffic on a current enforcement target, all the currents that compete are prevented according to this array.

Drawing 7 consists of one base bar 402 in the bottom where the five upper bars 404 cross, and shows the 5-bit WORD tree 400 with which the memory element 406 accumulated on each crossing was formed.

In drawing 11, the instantiation-approach for creating a memory element according to this invention is illustrated from drawing 8 . As shown in drawing 8 , a wafer 500 possesses the up conductivity layer 501, and the magnetic multilayer structure 502 is first arranged on the thick base flow layer on an insulating substrate 506. In the example of drawing 8 , it is silicon 508 on silicon carbide 510 in an insulating substrate 506. It cannot be overemphasized that the substrate to be used is not serious for this invention. The other insulating substrate used by fabrication of an electro nick memory element can also be used.

Next, as shown in drawing 9 , the sensitization layer 512 is arranged on the up conductivity layer 501, and a line (about 1 micrometer in thickness [Usually]) 514 is limited in the insulating layer by the conventional photolithography method. and the multilayer exposed by the line 514 as shown in drawing 10 -- ion grinding of the part of 506 is carried out to an insulating substrate 506, and a photoresist layer 512 is removed.

As shown in drawing 11 after it, the top face of the assembly illustrated in drawing 10 is flattened in the layer 516 which consists of an insulator like a polyamide, SiO, or SiNi. This front face is flattened by a suitable etching technique or grinding technique to the front face of 514 after that. And different photoresist matter is arranged on the front face [finishing / flattening] formed of the top face of a metal wire 514 and an insulating layer 516. A line 518 is limited in a photoresist layer 519 at right angles to a metal wire 514 after that (usually **** 1 Micron) (drawing 12). And a conductive metal is arranged and a line 518 is filled up with the metal of lead-wire nature. After a photoresist layer 518 is removed, the conductive metal wire 520 remains and the top face of a metal wire 514 is contacted.

Drawing 14 a and drawing 14 b show the flat-surface memory element 700 according to this invention. As for close, in this example, a conductive path is thoroughly in the flat surface of an element 700. The conductor layers 702 and 704 put the multilayer structure between which the ferromagnetic layers 706 and 708 put the non-ferromagnetism layer 710. Like the case of examples other than this of this invention, the ferromagnetic layer 706 is fixed (exchange bias processing which used the antiferromagnetism layer which is pinched among layers 706 and 702 (not shown) and usually contacts those layers), and the ferromagnetic layer 708 is manufactured so that it may have the two desirable directions of orientation (a pairs of drawing 14 drawing 14 b). In this example, only the ferromagnetic layer 706 carries out orientation of that magnetic moment at right angles to a conductive path. Actuation of the ferromagnetic memory element of drawing 14 a and drawing 14 b is similar to the actuation explained about the example of drawing 1. Furthermore, all matter can be used for the flat-surface memory element according to this invention, and it can be adapted so that all effective corrections may be used by the design of the element (for example, the "hard" ferromagnetism layer and "elasticity" ferromagnetism layer which are accumulated by turns) accumulated perpendicularly.

Drawing 15 shows the random access x-y array 800 which consists of the flat-surface ferromagnetism element 700 according to this invention. Although incoming line 802 contacts the memory element 700 on the top face of the conductor layer 704, incoming line 804 contacts the underside of the conductor layer 702. Duplication of incoming line 802 and 804 is suppressed to the minimum by the array across an element.

Incoming line 802 and 804 and lead wire 702 and 704 can be easily manufactured according to an everyday fabrication process and an arrangement process. The multilayer structure possessing the layers 706 and 708 firmly separated by the layer 710 must be manufactured by the technique which realizes an interface without contamination like for example, processing within a vacuum.

The line processing within a vacuum effective in creating the array of the flat-surface magnetism memory element shown in drawing 15 is shown in drawing 16 a and 16b, 16c, and 16d. After creating the grid of service wire on an insulating substrate 804, the contact pads 806 (usually Cu) with which a memory element with a magnetic band is built on it are left behind to service wire. A wafer 900 is thoroughly covered with a photoresist layer 902, and is arranged in vacuum devices (not shown). the ferromagnetic magnetic bands 704 and 706 -- the groove in each location is selectively left to the bottom to the top-face substrate 804 by the focusing ion beam, and grinding is carried out (drawing 16 b). A ferromagnetic (it is (like Co)) metal is the object which carries out contact electric enough to the exposed Cu walls 702a and 704a, and it is carefully arranged so that it may be thoroughly filled up with grooves 906 and 908, so that it may be illustrated by drawing 16 c. Since a wafer 900 is removed from vacuum devices and a photoresist layer 902 is removed, a superfluous ferromagnetic metal is removed from a layer 904, and the memory element 700 with a magnetic band remains.

An annular configuration can be utilized and the ferromagnetic band random-access-memory element according to this invention can also be realized so that it may be illustrated by drawing 17. With a certain annular configuration 1000, the external ring 1002 is conductive non-magnetic metal most. ((like pure rod and hollow tubing, an annular ring, or a real dotted line) It is) The conductive layer 1004, i.e., a line, is arranged at the core of an annulus. The pair of the ferromagnetic layers 1006 and 1008 between which each set puts the conductive non-magnetic metal layer 1010 resides permanently between the internal layers 1004, i.e., a line, most with the external layer 1002. Each ferromagnetic layers 1006 and 1008 are magnetic-pole-ized so that orientation of the easy shaft of the magnetic-moment mu may be carried out in either right-handed rotation or the left-handed rotation. But since the magnetic moment of an external ferromagnetic layer is fixed, the antiferromagnetism layer 1112 may be most arranged between external ferromagnetic layers with an external conductive layer.

Between [the resistance to flow J of the current of the radial of an element / orientation of all of magnetic-moment mu of the ferromagnetic layers 1006 and 1008 is carried out in the same direction (right-handed rotation or left-handed rotation on the other hand) that is, / magnetic-moment mu of that it is being in an alignment condition, or the ferromagnetic layers 1006 and 1008] right-handed-rotation orientation and left-handed-rotation orientation (i.e., in this array, it is dependent on whether it appears by turns continuously in the state of anti-alignment so that it may be illustrated.)

Setting in another annular configuration (drawing 18), a memory element is a ring 2002 (non-magnetic metal).

It consists of multistory structures 2000 which consist of 2004 (it is ferromagnetism and magnetic-moment mu as shown by the arrow head), 2006 (non-magnetic metal), 2008 (it is ferromagnetism and magnetic-moment mu as shown by the arrow head), and 2011 (non-magnetic metal), and it has the magnetization direction similar to drawing 4 which is the same or appears by turns, and the ferromagnetic layers 2004 and 2008 have the electric contact sections 2010 and 2012 in the upper part and the pars basilaris ossis occipitalis of the multistory structure 2000, in order to ask a question about magnetic resistance of multistory structure. however, the conductor with which the core of multistory structure is insulated from the multistory structure element itself by the insulating layer 2014 -- it was replaced by "rod" 2013. When [required] you case or wish, the antiferromagnetism layer 2016 is put between a non-magnetic layer 2002 and the ferromagnetic layer 2004. Flow J of a current is axial flow which lets a multistory structure element pass.

In both aforementioned annular configurations, a magnetic element is built so that it may become the closeout magnetism circuit which is either a hollow cylinder in the 1st configuration, or the hollow washer of the 2nd configuration. The memory element which a circumference field does not have in these closeout magnetism circuits, therefore adjoins can be mounted very densely. In order "to write in" in information into an element in both the case, one of the annular patterns of parallel or reverse parallel must generate magnetic flux to the magnetic flux in annular magnetism components. As one method of performing this, it performs through the central electric lead wire 1004 or 2013. Needless to say, it is realizable in order that techniques other than this may also attain this actuation.

The ferromagnetic metal layer according to this invention can also be created from which ferromagnetic material. for example, a ferromagnetic layer -- Fe, Co, and nickel -- or (a permalloy and U.S.P. -- the magnetic alloy described by 4,402,770 and 4,402,043 is included.) to Norman, C, and Coon, both come out, and there are, and it is thoroughly taken in in this description -- the alloy can be used. A conductive antiferromagnetism metal and its alloy can be used for an electric target like Cu, Pt, Ag, and Au at an antiferromagnetism layer. When using a hard ferromagnetism layer and an elasticity ferromagnetism layer, Co (the hard super-magnetism alloy described by U.S.P.4,402,770 to Norman, C, and Coon is included), While Fe or the hard magnetic substance like the alloy can be used, nickel, Fe, Co, and its alloy can be used for the elasticity magnetic substance (the elasticity magnetic substance described by U.S.P.4,409,043 to a permalloy, Norman and C, and Coon is included). When an antiferromagnetism layer is used, Cr like FeMn or the rare earth content matter, n, or its alloy can be used.

Generally, the ferromagnetic layer used by this invention has the desirable thickness of about 50 to about 100A for there being thickness of about 10 to about 100A, and making a fabrication easy. Similarly, the antiferromagnetism layer used by this invention is usually 10 to about 100A in thickness, and its thickness of about 50 to about 100A is desirable for making a fabrication easy.

In the aforementioned fabrication technique, especially the photoresist matter and insulating layer that are used are not serious. In such fabrication techniques, all the photoresist matter and insulating materials that are generally used by the electronics fabrication are effective ****.

Clearly, in consideration of the aforementioned instruction, many corrections and deformation of this invention are possible. Therefore, he should understand that it can practice within the limits of an accompanying claim also besides having described especially this invention.

[Translation done.]

* NOTICES *

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damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]

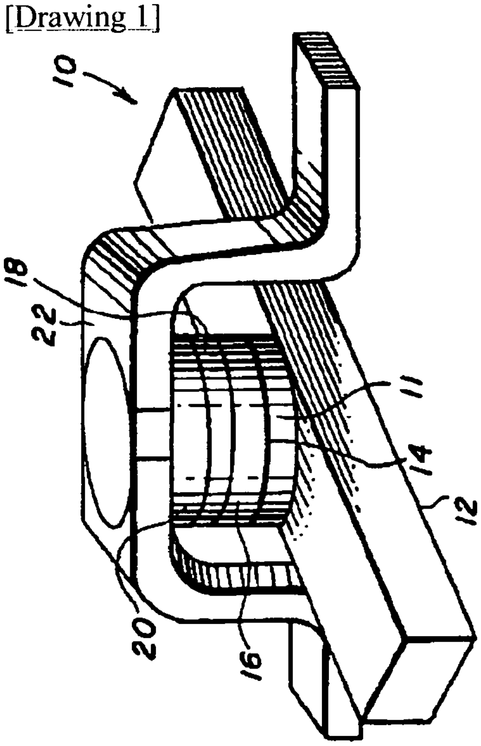


FIG. 1

[Drawing 2]

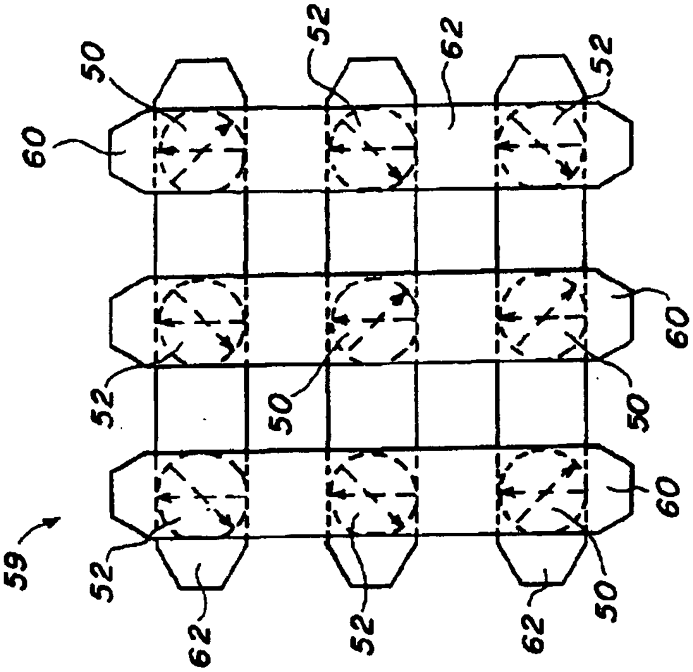


FIG. 2

[Drawing 3]

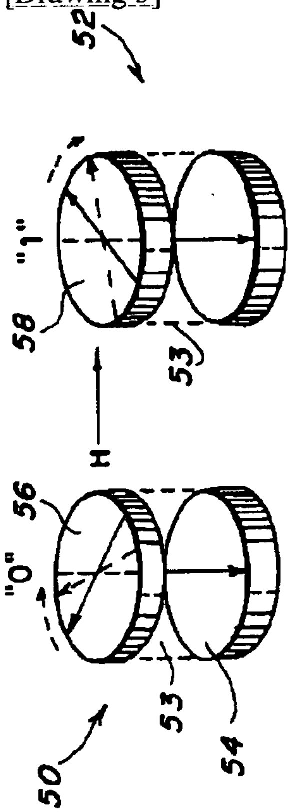


FIG. 3

[Drawing 4]

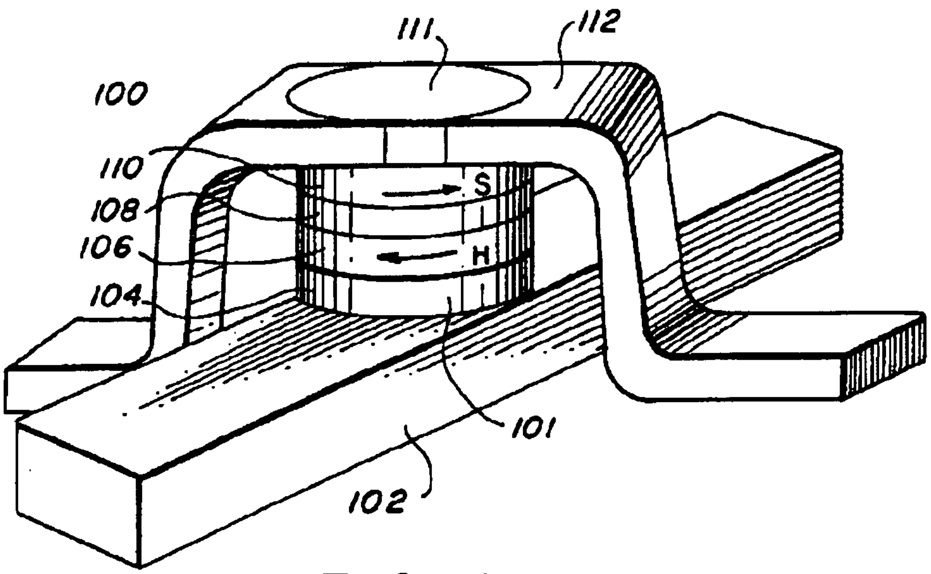


FIG. 4

[Drawing 5]

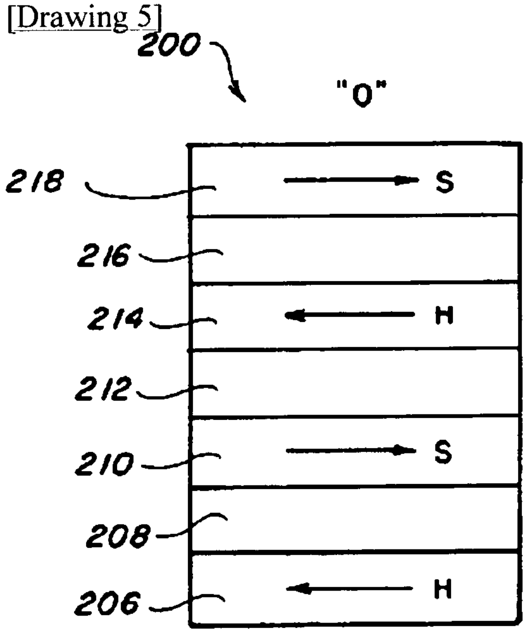


FIG. 5a

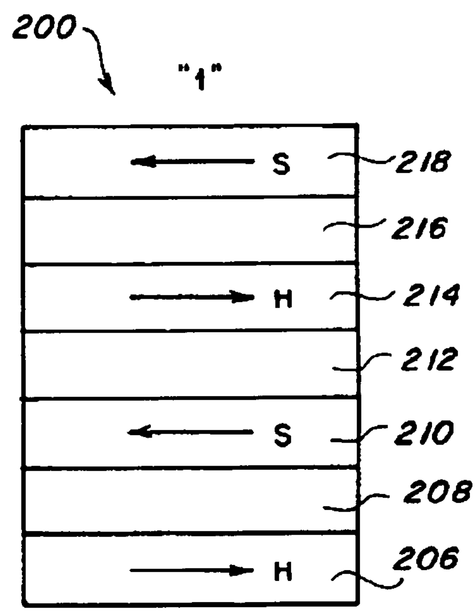


FIG. 5b

[Drawing 6]

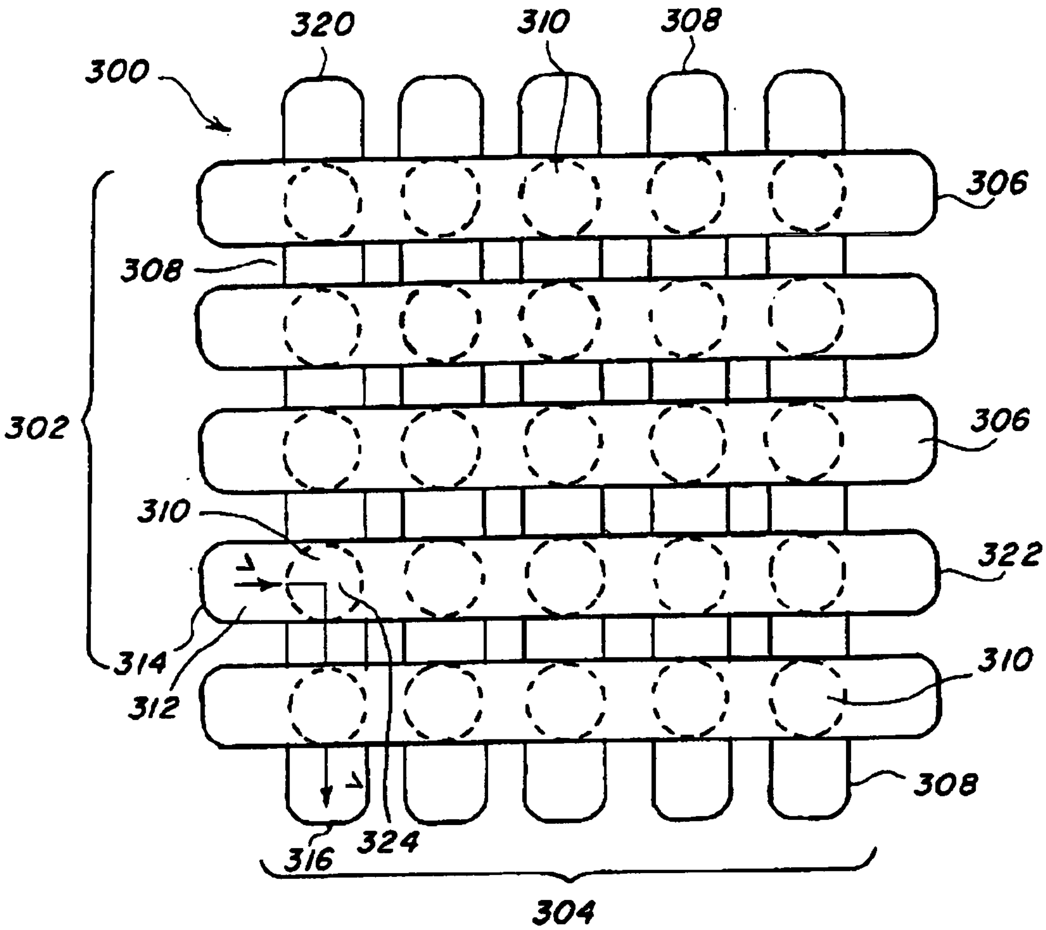


FIG. 6

[Drawing 7]

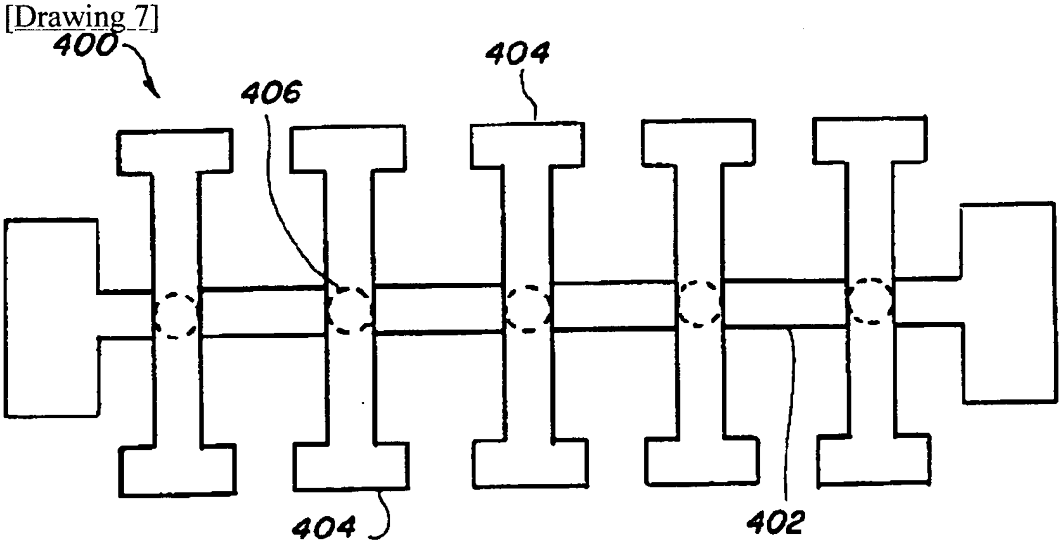


FIG. 7

[Drawing 8]

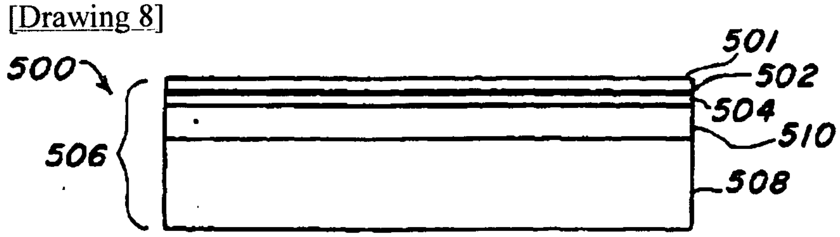


FIG. 8

[Drawing 9]

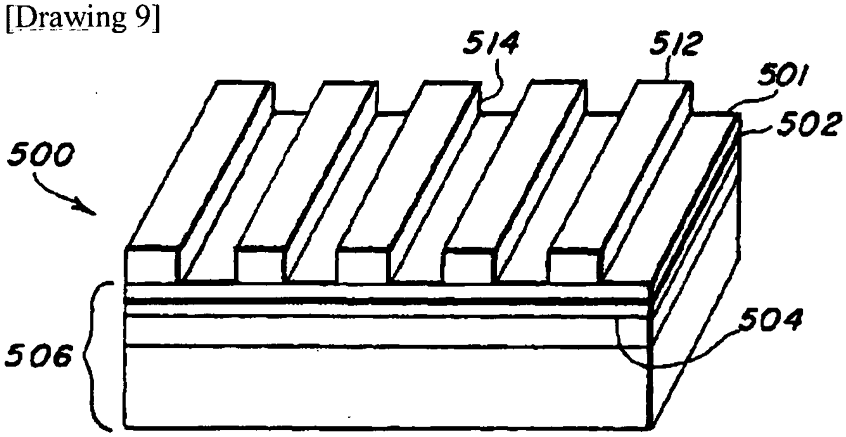


FIG. 9

[Drawing 10]

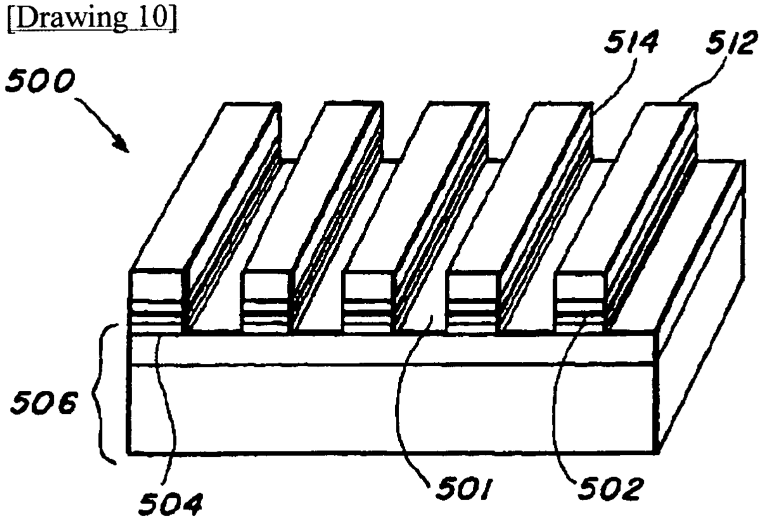


FIG. 10

[Drawing 11]

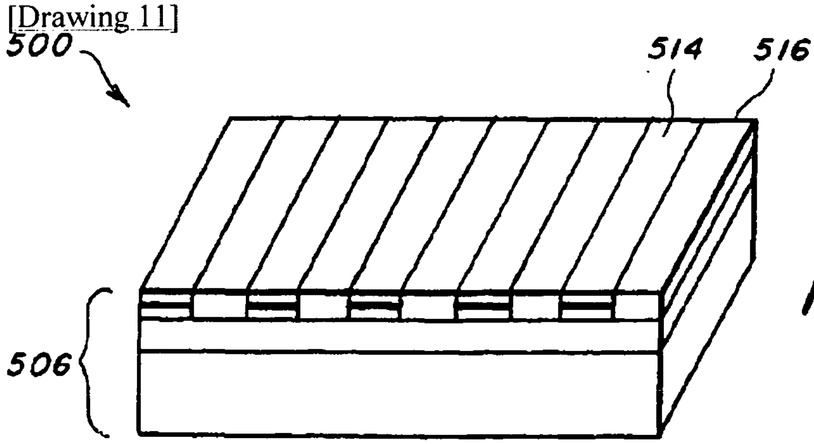


FIG. 11

[Drawing 12]

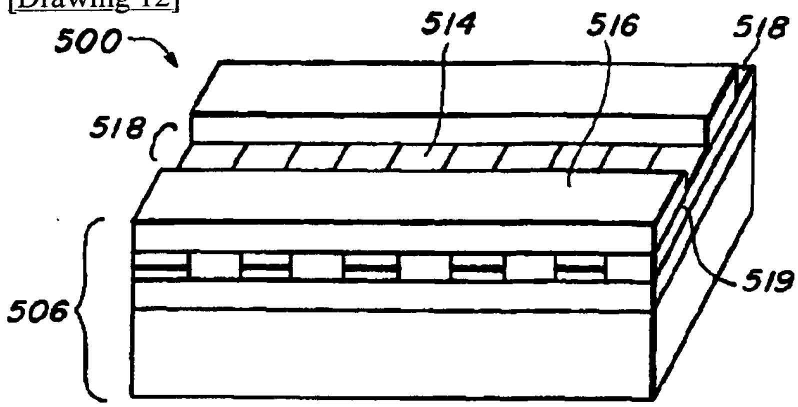


FIG. 12

[Drawing 13]

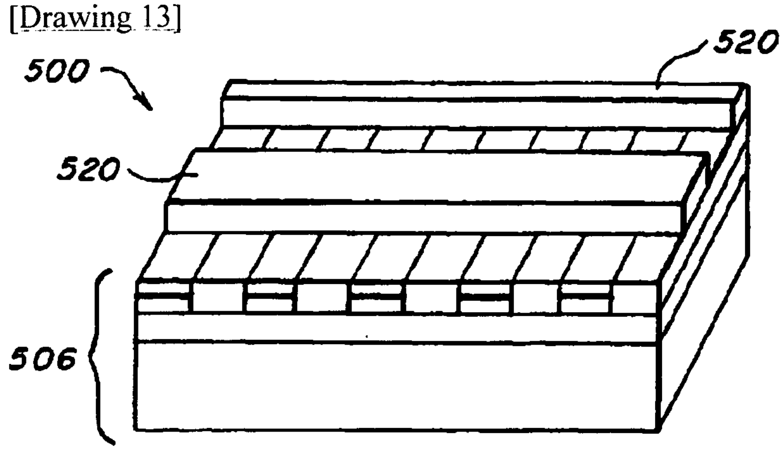


FIG. 13

[Drawing 14]

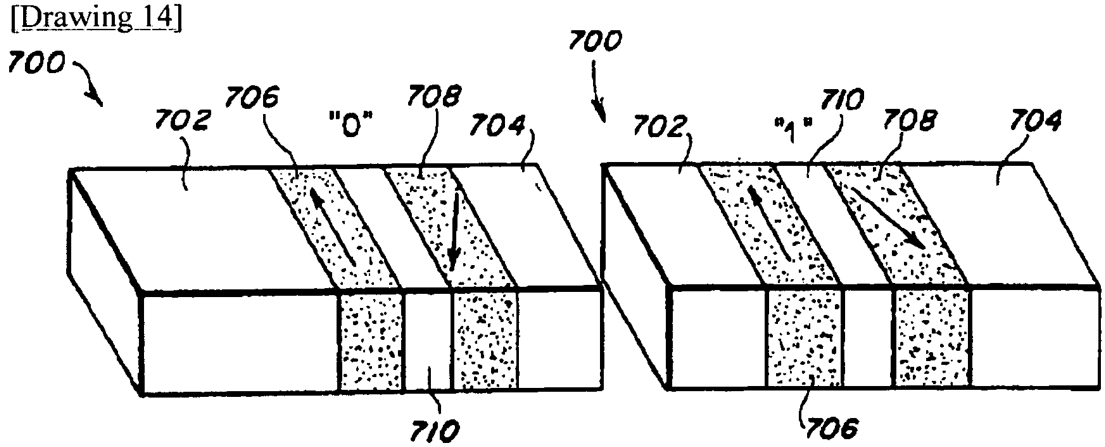
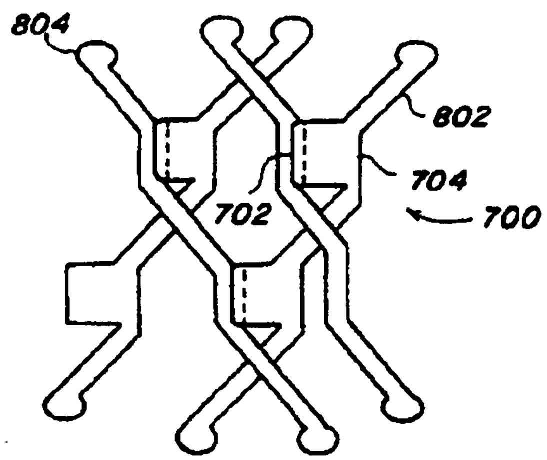


FIG. 14a FIG. 14b

[Drawing 15]

FIG. 15



[Drawing 16]

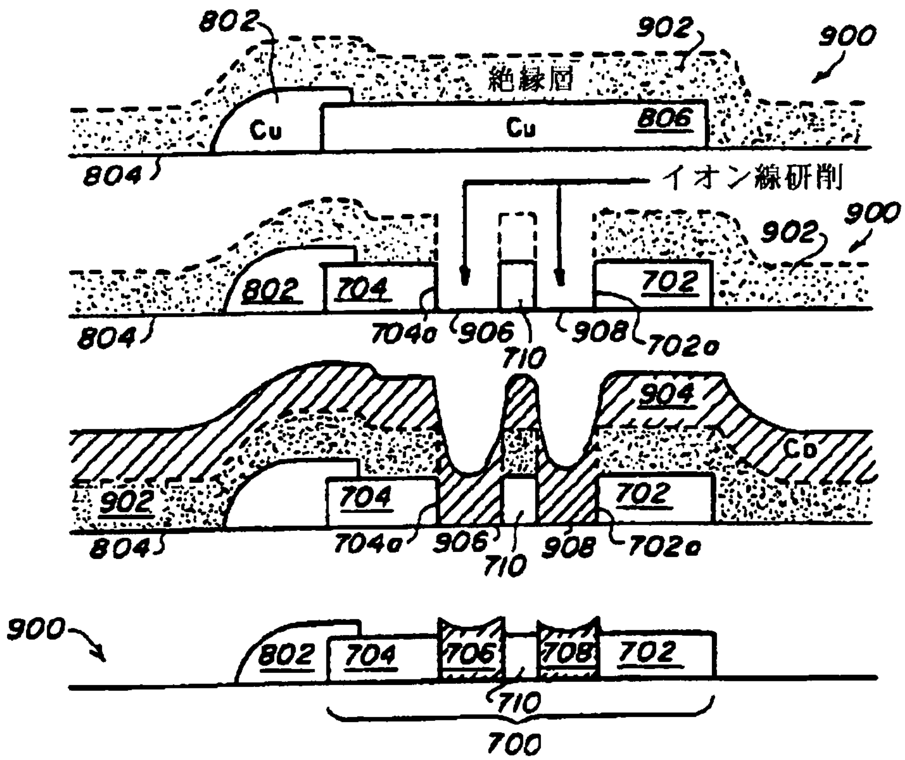


FIG. 16a
FIG. 16b
FIG. 16c
FIG. 16d

[Drawing 17]

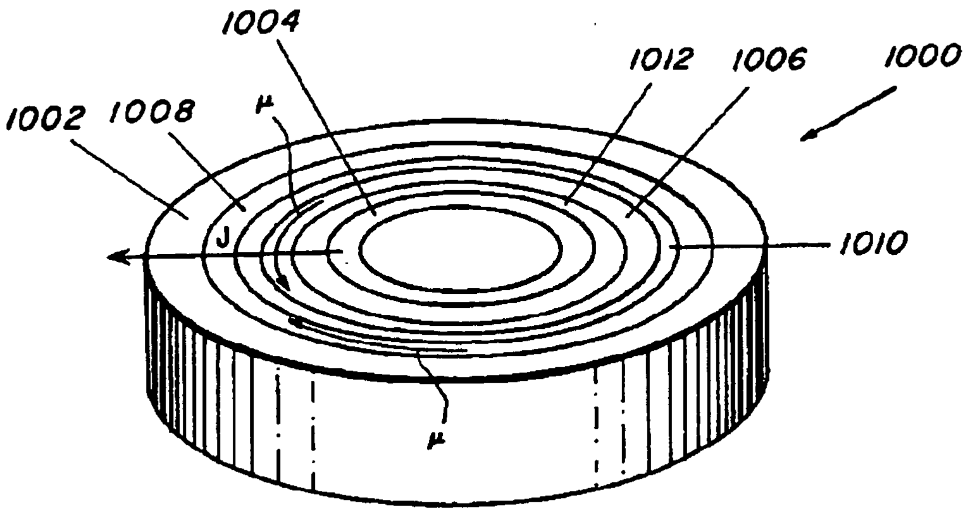


FIG. 17

[Drawing 18]

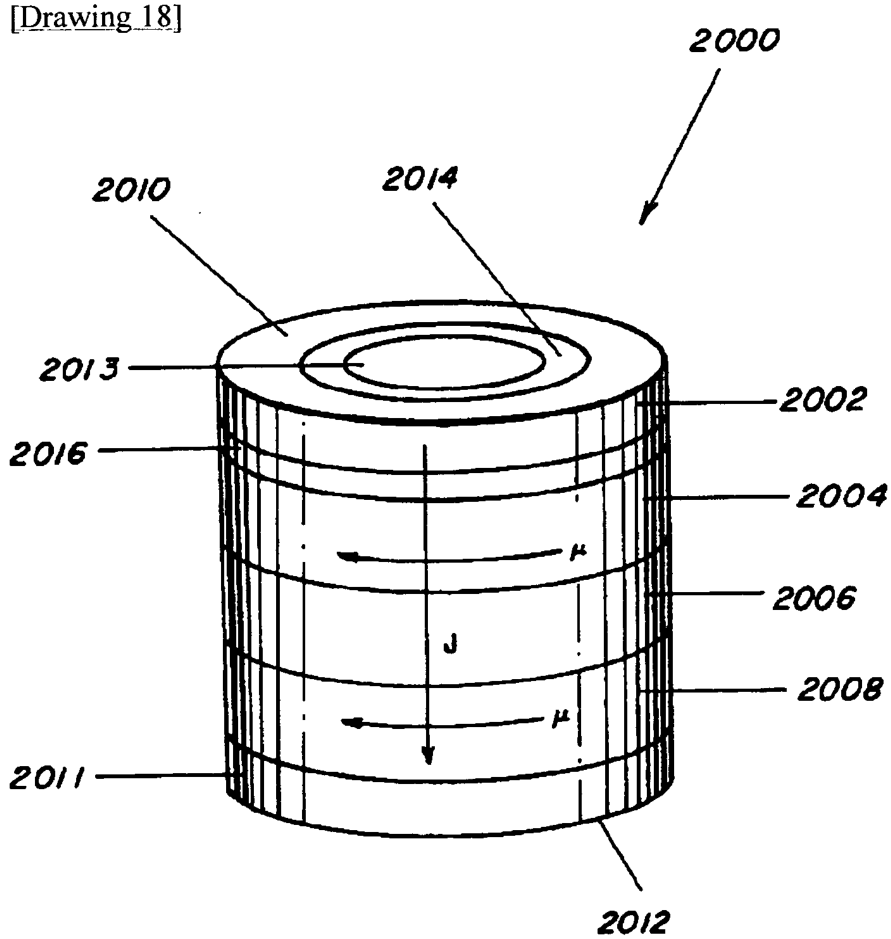


FIG. 18

[Translation done.]